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A Comparison of the Postdeployment Hospitalization Experience of U.S. Military Personnel Following Service in the 1991 Gulf War, Southwest Asia After the Gulf War, and Bosnia

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Much attention has been given to the impact of deployment on the health of veterans from the 1991 Gulf War. Whereas increases in self-reported symptoms have been common, no specific exposures have been implicated. Some have suggested that stress from deployment is the chief cause for multisymptom conditions among Gulf War veterans, but comparisons with the health of other recent deployers have not been made. We sought to examine the impact of several large military deployments on hospitalization experience. Hospitalization records were examined for all active duty personnel deployed exclusively to the Gulf War, Southwest Asia after the Gulf War, or Bosnia. Cox's hazard modeling was used to assess time until first post-deployment hospitalization, separation from active duty, or December 31, 2000, whichever occurred first, while controlling for influential covariates and temporal changes. Personnel deployed to Southwest Asia after the 1991 Gulf War were at a slight increased risk for any-cause hospitalization and for 3 of the 14 major diagnostic categories when compared with veterans of the 1991 Gulf War. Personnel deployed to Bosnia were at a decreased risk for any-cause hospitalization and 12 of the 14 major diagnostic categories when compared with Gulf War veterans. These findings do not fully explain the complexity of postdeployment health experiences. Although the risk for hospitalization may be associated with regional deployment, it is unlikely that Gulf War veterans are at greater risk of hospitalization due to a specific exposure-related disease.

Keywords combat disorders, hospitalization, military medicine, Persian Gulf syndrome, veterans

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INTRODUCTION

Since the end of the 1991 Gulf War deployment period, a great deal of national and international attention has been paid to the investigation of possible exposure-related postwar illnesses.^(1–3) Military personnel returning from the 1991 Gulf War have reported a wide range of symptoms, including fatigue, cognition problems, and musculoskeletal conditions, which some have suggested may be related to service in the Gulf.^(4–11)

Etiologies for increased symptom reporting remain elusive, and epidemiologic studies of 1991 Gulf War veterans have found no increased risk of morbidity among Gulf War veterans, as measured by hospitalizations in active duty members within 2 years of the Gulf War,⁽¹²⁾ hospitalizations among members who did not seek care at Department of Defense (DoD) treatment facilities,⁽¹³⁾ hospitalizations for select diagnoses,⁽¹⁴⁾ or mortality due to diseases.^(15–18) Moreover, there was no significant difference found in posttraumatic stress disorder (PTSD) rates in Gulf War veterans when compared with those of personnel deployed to Bosnia.⁽¹⁹⁾ Additionally, epidemiologic investigations of the health impacts of specific war time exposures among Gulf War veterans found no excess hospitalizations among those personnel possibly exposed to nerve agents released as a result of the U.S. demolition of a munitions depot at Khamisiyah, Iraq,^(20–22) or for those personnel possibly exposed to the smoke from Kuwaiti oil well fires.^(22,23)

Whereas some have reported an increased risk of neurological impairment among Gulf War veterans,^(24–26) others did not find this association⁽²⁷⁾ nor an association between self-reported weakness/fatigue and the neuromuscular system.⁽²⁸⁾ Some research indicates that Gulf War veterans may be at risk for lower functional status, health-related quality of life problems, anxiety disorders, cognitive dysfunction, and PTSD when compared with those not deployed during the

same era.^(29–31) Recent deployment to Afghanistan and Iraq has been associated with increased self-reported PTSD and other mental health problems among veterans returning from combat.^(32,33) This is important in light of research done by Barrett and colleagues⁽³⁴⁾ who found that veterans with PTSD reported significantly more physical health symptoms and medical conditions than veterans without PTSD. Finally, efforts to identify a group of symptoms as a unique, Gulf War-related syndrome have not been successful.^(35–39)

Studies have indicated that life in the military is more psychologically and physically taxing than life in civilian society.^(40,41) Researchers suggest that sudden and prolonged deployment, separation from family or home, irregular work hours, training involving strenuous physical and mental exertion, application of technologically advanced weaponry, threat of exposure to unknown chemical or biological agents, frequent family dislocation, and a number of personal relationship stress factors^(42,43) may be the cause of increased symptom reporting during and after deployment.⁽⁴⁴⁾

Immediately following the end of the Gulf War period, U.S. military personnel were deployed for peacekeeping duty in Southwest Asia, with operations extending throughout the 1990s. During this time, the United States also deployed service members for peacekeeping duty in Bosnia. Reports have suggested that personnel involved in peacekeeping missions following wartime may have increased symptoms of psychological distress.^(45–50) Due to such conditions as war zone stress, witnessing atrocities, frustrations with peacekeeping, and restrictive rules of engagement, peacekeepers may be at greater risks for posttraumatic stress disorder,⁽⁴⁵⁾ disorders of extreme stress,^(51,52) and self-inflicted injuries.^(53,54) Others have found that soldier adaptation to isolation, ambiguity, powerlessness, boredom, and danger or threat explains the degree of stress experienced.⁽⁵⁵⁾

More than a decade since the 1991 Gulf War, research findings are still debated. With some past criticism voiced regarding the comparison of deployed personnel with those not deployed,⁽⁵⁶⁾ the current analyses use alternative comparison groups. The purpose of this study was to compare the postdeployment hospitalization experiences of veterans from the 1991 Gulf War and personnel involved in the peacekeeping missions following that war.

METHODS

Objectives

Specifically, we sought to determine whether differences existed in postdeployment hospitalization rates of 1991 Gulf War veterans, personnel deployed to Southwest Asia after the Gulf War, and personnel deployed to Bosnia. We analyzed hospitalization for any cause and hospitalization in each of 14 broad categories covered in *International Classification of Diseases*, 9th Revision, Clinical Modification (ICD-9-CM).⁽⁵⁷⁾ Secondary objectives included the identification of demographic risk factors associated with hospitalization

during the period August 1, 1991, to December 31, 2000, and specific diagnoses of interest to Gulf War veterans.

Population

The study population consisted of active duty military personnel who served in one of the following deployments for one or more days during the deployment period: (a) the Gulf War theater August 1, 1990–July 31, 1991 ($n = 458,727$); (b) Southwest Asia August 1, 1991–December 31, 1998 ($n = 254,080$); or (c) Bosnia December 1, 1995–December 31, 1998 ($n = 46,911$). Unlike Gulf War veterans, personnel were deployed multiple times to both Bosnia and Southwest Asia following the Gulf War. To compare similar populations, only single deployment personnel were included. The analysis of postdeployment hospitalization data was limited to regular active duty military personnel, since DoD automated inpatient hospitalization data were available for these personnel throughout the study period. Active duty personnel are rarely hospitalized outside the DoD medical system; therefore, data acquisition is virtually complete for this group. Reserve and National Guard personnel are hospitalized only within military facilities while on active duty status. Because this study focused on postdeployment hospitalization, these two groups were excluded from our analyses.

Demographic and deployment data were provided by the Defense Manpower Data Center, Monterey Bay, California. These data included a personal identifier (for linking purposes only), gender, marital status, service branch (Army, Navy, Marine Corps, Air Force, and Coast Guard), age (categorized by approximate quartile age groups: 17–22 years, 23–27 years, 28–33 years, and ≥ 34 years), combined race/ethnicity (white, black, Hispanic, and other), DoD primary occupational specialty (10 major groups, defined by the *DoD Occupational Conversion Manual*),⁽⁵⁸⁾ pay grade (enlisted and officer), deployment location, entry and exit deployment dates, basic active service date, and date of separation from military service. Demographic data reflected status at the time of deployment.

Hospitalization Data

Electronic hospitalization data included date of admission and up to eight individual discharge diagnoses for each hospitalization. These data were captured from all DoD military treatment facilities worldwide during the period of October 1, 1988, through December 31, 2000. Data were linked to deployment and demographic data using unique identifiers and date of birth. Only hospitalization events during postdeployment were examined. Diagnoses were coded according to the ICD-9-CM. Additionally, as in previous reports,^(12,20–23,59–61) a pre-deployment hospitalization covariate was created to denote an individual's hospitalization for any cause during the 12 months prior to his or her first deployment.⁽⁶²⁾ This covariate served as an indicator for inpatient health care utilization during those 12 months, such that any significant risk estimates found would more appropriately reflect a change in health due to the deployment and not to the service member's health care utilization prior to their deployment. These analyses did not consider the

decimal component of the ICD-9-CM diagnoses; instead, all diagnoses having the same whole numbers were considered the same. Electronic hospitalization data from hospitals outside the DoD system and outpatient data for the entire time period of this investigation were not available.

Study Outcomes

With a focus on the hospitalization experience as a whole, we examined hospitalizations due to all causes and hospitalizations due to diagnoses in 14 broad ICD-9-CM diagnostic categories. The categories of interest were infection and parasitic diseases; neoplasms; endocrine, nutritional, and metabolic diseases and disorders of the immune system; diseases of the blood and bloodforming organs; mental disorders; diseases of the nervous system and sense organs; diseases of the circulatory system; diseases of the respiratory system; diseases of the digestive system; diseases of the genitourinary system; diseases of the skin and subcutaneous tissue; diseases of the musculoskeletal system and connective tissue; symptoms, signs, and ill-defined conditions; and injury and poisoning. Additionally, we chose to analyze specific ICD-9-CM diagnoses that have previously been of concern to Gulf War veterans.^(14,20,25,61,63) These conditions included: amyotrophic lateral sclerosis, asthma, diabetes, fibromyalgia, malignant neoplasms, mononeuritis, muscular dystrophy, nephritis, rheumatoid arthritis, systemic lupus erythematosus, and testicular cancer.

Identification of any hospitalization occurring during the study period for the different deployment personnel was made using admission date, discharge date, discharge diagnoses, and deployment dates. The diagnostic fields were scanned in numeric order for the ICD-9-CM diagnoses of interest. Hospitalization dates were scanned in chronological order, retaining as events only the first hospitalization occurring after deployment, which meets the targeted outcome criteria specific to that category or unique diagnosis. Hospitalizations with ICD-9-CM diagnoses from the three diagnostic categories pertaining to pregnancy and childbirth were not included in this study.

Statistical Analysis

We compared the hospitalization experience of these three deployments by using Cox proportional hazards survival analysis modeling. This permitted us to control for delayed entry and early exit of personnel in the overall modeling time. Personnel were classified as having an event if they were hospitalized with the targeted outcome in any DoD military treatment facility worldwide. The up-to-10-year follow-up period was calculated from the end of the first deployment until hospitalization, separation from active duty military service, or December 31, 2000, whichever occurred first.

Univariate analyses were first performed to assess the significance of the demographic and deployment variables on the risk of any-cause hospitalization. The proportional hazards assumption was tested by visual inspection of cumulative distribution plots and tested by interaction terms between the main variables and time. The Cox model was extended to

include a time-dependent covariate to account for procedural changes over time within the study period. An exploratory model analysis was performed to further assess demographic and deployment variables for significant associations and possible confounding while simultaneously adjusting for all other variables in the model. Using SAS data management and statistical capabilities (version 9.0, SAS Institute, Cary, N.C.), adjusted hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated for deployment status and the significant demographic variables for these deployed groups. Although a number of analyses were performed, adjustment for multiple comparisons was not conducted in order to present full findings. Note that some findings may be spurious and due to chance.

RESULTS

Complete deployment and demographic data were available for 455,465 active duty Gulf War veterans not deployed subsequently to Southwest Asia or Bosnia. During the 10-year, 5-month observation period, separation from active duty service occurred in 95% of Gulf War veterans. There were more men (93.6%) than women, and most were Army personnel (51.9%), followed by Navy/Coast Guard (21.8%), Marines (16.7%), and Air Force (9.6%). Most Gulf War veterans were younger than 27 years (64.3%), 51.7% were married, 66.6% were white, and most (89.8%) were enlisted (Table I).

We had complete deployment and demographic data for 249,047 active duty personnel deployed to Southwest Asia after the Gulf War and not deployed subsequently to Bosnia or previously to the Gulf War. During the 9-year, 5-month observation period, separation from active duty service occurred in 66% of this group. There were more men (92.5%) than women, and most were Navy/Coast Guard personnel (52.6%), followed by Air Force (26.6%), Army (12.3%), and Marines (8.5%). Most service members deployed to Southwest Asia were younger than 27 years (65.3%), 44.7% were married, 74.2% were white, and most (89.5%) were enlisted (Table I).

Complete deployment and demographic data were available for 44,341 active duty personnel deployed to Bosnia but not previously deployed to the Gulf War or Southwest Asia after the Gulf War. During the 5-year, 1-month observation period, separation from active duty service occurred in 46% of service members deployed to Bosnia. There were more men (88.6%) than women, and most were Army personnel (75.8%), followed by Air Force (17.0%), Navy/Coast Guard (6.4%), and Marines (0.8%). Most personnel deployed to Bosnia were younger than 27 years (66.1%), 49.1% were married, 66.4% were white, and most (88.9%) were enlisted (Table I).

Occupational specialties were proportionally similar between Gulf War veterans and service members deployed to Bosnia, with the following exceptions: Gulf War veterans had proportionally more electrical/mechanical repair workers and proportionally fewer functional support specialists and service and supply handlers. The cohort containing service members deployed to Southwest Asia had proportionally more

TABLE I. Characteristics of Active Duty Service Members Deployed Only to the Gulf War, Southwest Asia Following the Gulf War, or Bosnia (August 1, 1990 to December 31, 2000)

Characteristics	1991 Gulf War Veterans <i>N</i> = 455,465 (%)	Service Members Deployed Only to Southwest Asia <i>N</i> = 249,047 (%)	Service Members Deployed Only to Bosnia <i>N</i> = 44,341 (%)
Gender			
Male	93.6	92.5	88.6
Female	6.4	7.5	11.4
Age at time of deployment (years)			
17–22	34.8	38.4	31.8
23–27	29.5	26.9	34.3
28–33	19.1	17.3	17.8
34–65	16.6	17.4	16.1
Predeployment hospitalization			
No	92.6	95.8	95.3
Yes	7.4	4.2	4.7
Marital status			
Single	48.3	55.3	50.9
Married	51.7	44.7	49.1
Military pay grade			
Officer	10.2	10.5	11.1
Enlisted	89.8	89.5	88.9
Race/ethnicity			
Black	24.0	17.4	22.0
White	66.6	74.2	66.4
Hispanic	3.6	7.1	10.7
Other	5.8	1.3	0.9
Branch of service			
Air Force	9.6	26.6	17.0
Army	51.9	12.3	75.8
Navy and Coast Guard	21.8	52.6	6.4
Marines	16.7	8.5	0.8
Occupational category			
Electronic equipment repair	7.9	16.3	8.5
Combat specialties	27.7	7.6	25.5
Communications/intelligence	10.8	8.9	11.2
Health care	5.5	3.2	5.2
Other technical	2.3	3.6	2.5
Functional support	11.5	16.7	14.2
Electrical/mechanical repair	19.1	27.3	16.1
Craft workers	3.6	15.8	2.8
Service and supply	10.3	6.9	13.3
Students, prisoners, other	1.3	3.7	0.7

specialists trained in electronic equipment repair, functional support, electrical/mechanical repair, and craft work, and fewer trained in combat specialties than either the Gulf War or Bosnia cohorts (Table I).

Postdeployment hospitalizations occurred in 17.1% of the Gulf War veterans, 11.1% of the personnel deployed to Southwest Asia after the Gulf War, and 7.4% of the personnel de-

ployed to Bosnia. On assessment of univariate analyses, we included the following variables in further multivariable modeling: gender, age, race/ethnicity, marital status, pay grade, length of service, predeployment hospitalization, service branch, and occupation. Collinearity diagnostics identified multicollinearity between age, length of service, and pay grade; therefore, length of service was removed from further modeling.

On investigation of cumulative distribution plots and time interaction terms, we found evidence to suggest a violation of the proportional hazards assumption. Therefore, we included a time-dependent covariate to account for changes in hospitalization methods, diagnostic criteria, procedures, and other time dependencies within the study period.

Theater-specific adjusted risk of any-cause hospitalization separated by service branch can be found in Table II. Army and Marine Corps service members deployed to Southwest Asia had a decreased risk of hospitalization when compared with Army and Marine Gulf War veterans (HR = 0.91; 95% CI: 0.86, 0.97, HR = 0.54; 95% CI: 0.44, 0.66, respectively), whereas those in the Navy/Coast Guard had an increased risk of hospitalization (HR = 1.15; 95% CI: 1.11, 1.19) when compared with Navy/Coast Guard Gulf War veterans. Among Navy/Coast Guard personnel, those deployed to Bosnia had an increased risk of hospitalization (HR = 1.19; 95% CI: 1.04, 1.36), whereas all other service branches were significantly less likely to be hospitalized when compared with Gulf War veterans.

Other significant findings revealed that women, personnel who were older, enlisted, and hospitalized prior to deployment were at increased risk for hospitalization, regardless of service branch. Married Air Force personnel were at decreased risk for hospitalization (HR = 0.94; 95% CI: 0.91, 0.98), whereas married Army and Navy/Coast Guard personnel were at increased risk for hospitalization (HR = 1.06; 95% CI: 1.04, 1.09, HR = 1.07; 95% CI: 1.04, 1.10, respectively) when compared with personnel who were single. White Army personnel were at a slightly increased risk (HR = 1.07; 95% CI: 1.05, 1.09), whereas Hispanic Navy/Coast Guard and Marines were at a decreased risk for hospitalization when compared with blacks (HR = 0.84; 95% CI: 0.79, 0.88, HR = 0.85; 95% CI: 0.76, 0.95, respectively).

Finally, when considering occupation, health care workers were at the most elevated risk for hospitalization when compared with electronic equipment repair workers for all service branches, with the exception of the Marines. Marines who were categorized as students, prisoners, or with another nonoccupational status were at the highest risk for hospitalization (HR = 1.14; 95% CI: 1.04, 1.25) when compared with electronic equipment repair workers.

Extended Cox time-to-event modeling was completed for each of 14 ICD-9-CM broad categories, with Gulf War veterans as the reference. Service members deployed to Southwest Asia after the Gulf War were more likely to be hospitalized for the majority of the broad ICD-9-CM categories. They were significantly more likely to be hospitalized for mental disorders (HR = 1.34; 95% CI: 1.26, 1.43), injury and poisoning (HR = 1.12; 95% CI: 1.06, 1.19), and diagnoses of the musculoskeletal system (HR = 1.06; 95% CI: 1.01, 1.12). Service members deployed to Bosnia were at significantly lower risk for hospitalization in all broad categories when compared with Gulf War veterans, with the exception of blood diseases (HR = 0.93; 95% CI: 0.75, 1.15) and mental disorders (HR = 1.08; 95% CI: 0.96, 1.21). They were least likely to be hospitalized for

diseases of the skin (HR = 0.57; 95% CI: 0.46, 0.71), digestive system (HR = 0.60; 95% CI: 0.54, 0.67), genitourinary system (HR = 0.60; 95% CI: 0.51, 0.70), and neoplasms (HR = 0.61; 95% CI: 0.50, 0.76) (Table III).

Additional modeling of specific diagnoses of concern to Gulf War veterans is presented in Table IV. Personnel deployed to Bosnia were significantly less likely to be hospitalized post-deployment for mononeuritis when compared with Gulf War veterans (HR = 0.55; 95% CI: 0.35, 0.88). No other specific diagnoses were found to be statistically significant. Due to sparse outcome data, measures could not be estimated for amyotrophic lateral sclerosis.

DISCUSSION

A tremendous amount of research time and resources has been spent investigating the health of 1991 Gulf War veterans since the war more than 14 years ago. Previous hospitalization studies have found no excess of unexplained hospitalization among Gulf War veterans,^(12,13,64) although association with service in the first Gulf War and some specific diagnoses have been reported.^(5,6,65) In addition, fatigue, cognition problems, musculoskeletal conditions, functional status, and anxiety disorders have been reported more frequently in service members deployed to the Gulf War than in those nondeployed.^(4-11,29-31)

However, there has been some criticism regarding comparison of deployed personnel with those not deployed and what impact this "healthy deployer" effect might have on results.⁽⁶⁶⁾ Therefore, we compared 1991 Gulf War veterans with personnel deployed to the same geographic location immediately following the Gulf War, and personnel deployed to Bosnia during approximately the same time period. For any-cause hospitalization, among Army personnel and among Marines, we found those deployed to Southwest Asia following the Gulf War or Bosnia to be at a significant decreased risk for hospitalization. Among Navy/Coast Guard personnel, we found those deployed to Southwest Asia or Bosnia to be at a significant increased risk for hospitalization. Finally, among Air Force personnel, those deployed to Bosnia were found to be at decreased risk for any-cause hospitalization; however, those deployed to Southwest Asia were not significantly different from Gulf War veterans.

One possible explanation for the lower hazard ratios seen in those deployed to Bosnia may be the shorter lengths of follow-up in adequately capturing latent disease in this deployment group. The observation period for those deployed to Bosnia was 5 years and 1 month compared with an observation period of 10 years and 5 months for the Gulf War group, and 9 years and 5 months for the Southwest Asia group. However, the data were reanalyzed reducing the follow-up time to 5 years postdeployment for all three groups, with only minor changes in risk estimates and 95% confidence intervals, and no change in significance or overall conclusions found (data not shown). This would suggest a more constant rate of hospitalization over time among the three deployed groups. The differences may

TABLE II. Adjusted Hazard Ratios and 95% Confidence Intervals for the Outcome of Any-Cause Postdeployment Hospitalization Among Active Duty Service Members Deployed to the Gulf War, Southwest Asia Following the Gulf War, and Bosnia (August 1, 1990 to December 31, 2000)

Characteristics	Army <i>N</i> = 300,598		Navy/Coast Guard <i>N</i> = 233,129		Marines <i>N</i> = 97,625		Air Force <i>N</i> = 117,501	
	Percent ^A	HR ^B (95% CI)	Percent ^A	HR ^B (95% CI)	Percent ^A	HR ^B (95% CI)	Percent ^A	HR ^B (95% CI)
Theater								
Gulf War ^C	14.9	—	6.5	—	10.7	—	6.3	—
Southwest Asia	1.4	0.91 (0.86, 0.97)	5.9	1.15 (1.11, 1.19)	1.6	0.54 (0.44, 0.66)	6.8	1.06 (1.00, 1.12)
Bosnia	0.9	0.50 (0.46, 0.54)	0.1	1.19 (1.04, 1.36)	<0.1	0.46 (0.29, 0.72)	0.4	0.78 (0.69, 0.88)
Gender								
Male ^C	15.0	—	11.5	—	12.0	—	11.6	—
Female	2.2	1.55 (1.50, 1.59)	1.0	1.51 (1.45, 1.58)	0.3	1.79 (1.60, 2.00)	1.9	1.55 (1.48, 1.63)
Age at deployment (years)								
17–22 ^C	4.9	—	4.1	—	5.7	—	2.6	—
23–27	4.8	1.02 (0.99, 1.04)	2.9	0.95 (0.92, 0.99)	2.8	0.92 (0.88, 0.97)	3.5	0.90 (0.86, 0.95)
28–33	3.8	1.15 (1.12, 1.19)	2.6	1.09 (1.05, 1.13)	2.1	1.15 (1.08, 1.22)	3.7	1.02 (0.96, 1.07)
34–65	3.7	1.39 (1.35, 1.43)	2.9	1.26 (1.21, 1.31)	1.7	1.37 (1.29, 1.47)	3.7	1.16 (1.10, 1.23)
Predeployment hospitalization								
No ^C	15.1	—	11.6	—	11.5	—	12.0	—
Yes	2.0	1.61 (1.56, 1.65)	0.9	1.80 (1.72, 1.88)	0.9	1.52 (1.42, 1.63)	1.4	1.78 (1.69, 1.88)
Marital status								
Single ^C	7.1	—	6.1	—	6.3	—	4.9	—
Married	10.0	1.06 (1.04, 1.09)	6.4	1.07 (1.04, 1.10)	6.1	1.04 (0.99, 1.02)	8.5	0.94 (0.91, 0.98)
Military pay grade								
Officer ^C	2.0	—	1.3	—	1.1	—	1.9	—
Enlisted	15.2	1.22 (1.18, 1.26)	11.3	1.29 (1.23, 1.35)	11.3	1.31 (1.22, 1.41)	11.5	1.14 (1.07, 1.21)
Race/ethnicity								
Black ^C	5.4	—	2.3	—	2.3	—	2.1	—
White	10.3	1.07 (1.05, 1.09)	8.9	1.02 (0.97, 1.09)	8.9	1.04 (1.00, 1.09)	10.7	1.00 (0.96, 1.05)
Hispanic	0.7	0.96 (0.92, 1.00)	0.7	0.84 (0.79, 0.88)	0.3	0.85 (0.76, 0.95)	0.4	0.94 (0.85, 1.04)
Other	0.7	1.00 (0.95, 1.05)	0.6	1.03 (0.97, 1.09)	0.8	0.94 (0.87, 1.02)	0.3	0.99 (0.86, 1.11)
Occupational category								
Electronic equip repair ^C	1.1	—	1.8	—	1.3	—	1.3	—
Combat specialties	4.8	1.06 (1.02, 1.10)	1.4	1.09 (1.04, 1.14)	4.1	1.06 (0.99, 1.13)	1.3	0.93 (0.86, 1.01)
Communications/intelligence	2.1	0.99 (0.95, 1.03)	1.2	0.98 (0.93, 1.03)	1.1	0.95 (0.87, 1.03)	0.8	1.05 (0.96, 1.14)
Health care	1.4	1.29 (1.23, 1.35)	1.2	1.47 (1.40, 1.54)	<0.1	0.64 (0.44, 0.95)	0.9	1.38 (1.27, 1.50)
Other technical	0.5	1.03 (0.97, 1.09)	0.3	1.13 (1.04, 1.23)	0.3	0.98 (0.85, 1.12)	0.5	1.03 (0.94, 1.14)
Functional support	2.4	0.99 (0.95, 1.03)	1.6	1.02 (0.97, 1.07)	1.3	0.89 (0.82, 0.96)	2.7	1.10 (1.03, 1.17)
Electrical/mech repair	2.6	1.00 (0.95, 1.04)	3.5	1.05 (1.01, 1.09)	1.9	0.95 (0.88, 1.02)	3.3	1.11 (1.04, 1.18)
Craft workers	0.3	1.07 (0.99, 1.14)	0.8	1.15 (1.09, 1.22)	0.3	1.03 (0.91, 1.16)	1.0	1.11 (1.02, 1.20)
Service and supply	1.9	1.01 (0.97, 1.06)	0.7	1.15 (1.08, 1.21)	1.4	0.95 (0.88, 1.03)	1.4	1.10 (1.03, 1.19)
Students, prisoners, other	0.2	1.07 (0.98, 1.17)	0.2	1.11 (1.01, 1.23)	0.7	1.14 (1.04, 1.25)	0.3	1.27 (1.13, 1.44)

Notes: All models are adjusted for the following covariates: gender, age, marital status, pay grade, race/ethnicity, occupation, and predeployment hospitalization.

Bold indicates significant odds ratios. Dashes indicate reference categories.

^APercentage hospitalized among specified service branch.

^BHR = adjusted hazard ratio; CI = confidence interval.

^CReference category.

also be due to differing rates of separation over the study period explained by the dynamic nature of the peacekeeping missions. While newly deployed personnel were continuously adding to the Southwest Asia and Bosnia populations throughout most

of the follow-up period, Gulf War veterans were deployed to the war during a 1-year interval with no new personnel added for the remainder of their follow-up. This caused total attrition rates to be higher among Gulf War veterans for this study.

TABLE III. Adjusted Hazard Ratios for Postdeployment Hospitalizations by Major ICD-9-CM Categories Among Active Duty Service Members Deployed to Southwest Asia following the Gulf War, and to Bosnia Compared with Those Deployed to the Gulf War (August 1, 1990 to December 31, 2000)

ICD-9-CM Codes ^A	Major Categories of Diseases and Conditions	Gulf War ^B N = 455,465 Percent ^C	Southwest Asia N = 249,047		Bosnia N = 44,341	
			Percent ^C	HR ^D (95% CI)	Percent ^C	HR ^D (95% CI)
001–139	Infection and parasitic	1.4	0.8	1.03 (0.93, 1.13)	0.6	0.68 (0.57, 0.81)
140–239	Neoplasms	1.0	0.6	1.03 (0.93, 1.15)	0.4	0.61 (0.50, 0.76)
240–279	Endocrine and metabolic	1.0	0.8	1.02 (0.92, 1.13)	0.5	0.69 (0.57, 0.84)
280–289	Blood diseases	0.7	0.4	0.93 (0.80, 1.07)	0.5	0.93 (0.75, 1.15)
290–319	Mental disorders	2.5	1.9	1.34 (1.26, 1.43)	1.4	1.08 (0.96, 1.21)
320–389	Nervous system	1.2	0.7	1.01 (0.91, 1.12)	0.4	0.66 (0.54, 0.81)
390–459	Circulatory system	1.5	0.9	1.06 (0.97, 1.16)	0.5	0.70 (0.59, 0.83)
460–519	Respiratory system	2.0	1.3	1.08 (1.00, 1.16)	0.7	0.73 (0.63, 0.84)
520–579	Digestive system	3.7	2.4	0.99 (0.94, 1.05)	1.3	0.60 (0.54, 0.67)
580–629	Genitourinary system	1.8	1.1	1.00 (0.92, 1.09)	0.7	0.60 (0.51, 0.70)
680–709	Skin diseases	0.9	0.6	0.99 (0.88, 1.11)	0.3	0.57 (0.46, 0.71)
710–9739	Musculoskeletal system	5.1	3.1	1.06 (1.01, 1.12)	2.0	0.78 (0.71, 0.86)
780–799	Ill-defined conditions	2.0	1.3	1.03 (0.95, 1.11)	0.9	0.82 (0.71, 0.94)
800–999	Injury and poisoning	3.6	2.4	1.12 (1.06, 1.19)	2.0	0.80 (0.72, 0.88)

Notes: All models are adjusted for the following covariates: gender, age, marital status, pay grade, race/ethnicity, service branch, occupation, and predeployment hospitalization. **Bold** indicates significant odds ratios.

^AInternational Classification of Diseases, 9th Revision, Clinical Modification.

^BReference group.

^CPercentage hospitalized among specified theater.

^DHR = adjusted hazard ratio; CI = confidence interval.

A slight elevation in risk for hospitalization seen in Gulf War veterans when compared with nondeployed personnel has been explained by higher rates of hospitalization both before and after deployment. That is, lower rates of hospitalization during deployment increasing after troops return home is merely a regression to the mean induced by a selection effect and reduced accessibility to medical care during deployment.⁽⁶⁷⁾ Although dissimilarities in predeployment hospitalization may be present, we included a predeployment hospitalization indicator variable to adjust for any such potential differences. This variable alone cannot adjust for all variation in the complex characteristic of predeployment health; however, it is the best known surrogate for predeployment health in these populations and likely accounts for major morbidity prior to deployment. More likely, lower rates of hospitalization within those deployed to Bosnia represent a difference in access to care while in theater.

Brundage and colleagues^(62,68) described a higher rate of in-theater hospitalizations than postdeployment hospitalizations in personnel deployed to Bosnia. If those deployed to Bosnia were more apt to seek care and be hospitalized during deployment, this may explain their reduced risk for postdeployment hospitalization across all major diagnostic categories when compared with Gulf War veterans.

Across the majority of the broad ICD-9-CM groups, our results show similar hospitalization rates between Gulf War

veterans and service members deployed to Southwest Asia following the Gulf War, and lower hospitalization rates among personnel deployed to Bosnia. Although this may suggest that regional exposures such as dust or sand fleas may be responsible for these findings, with a particular exposure we would expect to see stronger measures of association within a specific diagnostic category (e.g., respiratory diseases or skin conditions) than in general across categories. Our findings do not suggest this. Our data more likely reflect differences in deployment with respect to differential use of in-theater care and differences in deployed populations themselves that are unquantifiable.

On June 7, 1994, in response to health concerns of Gulf War veterans, the DoD established the Comprehensive Clinical Evaluation Program (CCEP).^(59,60) The program was initiated to offer a systematic medical evaluation to 1991 Gulf War veterans still on active duty at any of 184 medical treatment facilities worldwide. Out of concern that this systematic increase in health-seeking behavior specific to Gulf War veterans might affect the validity of our findings,⁽⁶¹⁾ we removed all individuals who had enrolled in the CCEP as of February 1997⁽⁵⁹⁾ and reanalyzed our data. We found only a very small change in our measures of association that could not account for the lower risk for hospitalization in those deployed to Bosnia when compared with the 1991 Gulf War veterans (data not shown); therefore, we included all data in these analyses.

TABLE IV. Adjusted Hazard Ratios for Postdeployment Hospitalization for Specific Diagnoses Among Active Duty Service Members Deployed to the Gulf War, Southwest Asia following the Gulf War, and Bosnia (August 1, 1990 to December 31, 2000)

ICD-9 CM Codes ^B	Specific Diagnosis	Gulf War ^A N = 455,465 Percent ^C	Southwest Asia N = 249,047		Bosnia N = 44,341	
			Percent ^C	HR ^D (95% CI)	Percent ^C	HR ^D (95% CI)
354–355	Mononeuritis	0.27	0.13	0.88 (0.70, 1.10)	0.07	0.55 (0.35, 0.88)
493	Asthma	0.21	0.13	1.22 (0.96, 1.56)	0.11	0.86 (0.56, 1.31)
140–208	Malignant neoplasms	0.21	0.15	0.94 (0.74, 1.20)	0.11	0.82 (0.54, 1.24)
250	Diabetes	0.12	0.08	0.95 (0.69, 1.30)	0.04	0.54 (0.29, 1.00)
580–586	Nephritis	0.06	0.04	1.30 (0.84, 2.01)	0.02	0.47 (0.20, 1.08)
729.1	Fibromyalgia	0.04	0.02	0.96 (0.52, 1.77)	0.01	0.71 (0.22, 2.33)
186	Testicular cancer	0.03	0.02	0.64 (0.32, 1.28)	0.02	0.80 (0.27, 2.39)
340	Muscular dystrophy	0.02	0.01	0.19 (0.03, 1.42)	0.01	0.49 (0.05, 4.83)
714	Rheumatoid arthritis	0.01	0.01	1.56 (0.63, 3.84)	<0.01	0.99 (0.16, 6.19)
710.0	Systemic lupus erythematosus	0.01	0.01	2.10 (0.69, 6.38)	<0.01	0.58 (0.05, 6.50)
335.20	Amyotrophic lateral sclerosis ^E	<0.01	<0.01	—	<0.01	—

Notes: All models are adjusted for the following covariates: gender, age, marital status, pay grade, race/ethnicity, service branch, occupation, and predeployment hospitalization. **Bold** indicates significant odds ratios. Dashes indicate reference categories.

^AReference group.

^BInternational Classification of Diseases, 9th Revision, Clinical Modification.

^CPercentage hospitalized among specified theater.

^DHR = adjusted hazard ratio; CI = confidence interval.

^EHazard ratios and 95% confidence intervals could not be calculated due to sparse outcome data.

Previous research has suggested that 1991 Gulf War veterans may be experiencing increased neurological symptoms and conditions in addition to some self-reported mental impairment.^(24–26,29–31,69) However, our data suggest no difference in hospitalizations for diseases of the nervous system in those deployed to Southwest Asia after the Gulf War when compared with Gulf War veterans. Though personnel deployed to Bosnia did have reduced risk for hospitalizations in this category, we think it would be inappropriate to make any claims isolating their risk for hospitalization in a specific category when their risk is reduced across almost all major diagnostic categories. Additionally, our investigation of specific diagnoses that have been of interest to Gulf War veterans did not find a statistically significant association other than the reduced risk of mononeuritis experienced by Bosnian deployed personnel when compared with Gulf War veterans. However, several of these illnesses are rare and/or have long latency, such that there was not enough time to observe the number of events needed to make statistical inferences between these deployed groups. Subsequently, our data do not support the hypothesis that Gulf War veterans are experiencing hospitalizations for diseases of the nervous system in excess of other deployed groups.

These analyses have a number of limitations that should be considered. The analysis of postdeployment morbidity was limited to outcomes severe enough to warrant hospitalization. DoD outpatient data began to be routinely compiled and stored electronically beginning in 1997 and is limited with regard to reporting for several years following. Therefore, outpatient

data were not considered in these analyses, as the majority of Gulf War veterans would not be captured in the system by this point.

Differences in self-reporting of symptoms that have been documented elsewhere,^(5,7,9–11) were not considered in this analysis. In addition, regular active duty personnel were only included, since electronic military hospitalization data were only available for these personnel. Although U.S. Reserve and National Guard forces played a large role in these deployments, these personnel are generally not hospitalized in military facilities once they return to civilian life after deployment and, therefore, were not included in this investigation. Similarly, as there is little visibility of most service members' health care utilization after they separate from active duty, follow-up did not extend beyond date of separation.

We defined our theater cohorts to include active duty members who were deployed exclusively to only one of the three theaters: 1991 Gulf War, Southwest Asia after the Gulf War, and Bosnia. We believed it would be difficult to classify those individuals who served in more than one theater without suffering unquantifiable misclassification bias. It is possible these restrictions prevented the healthiest members, those with frequent multiple deployments, from being in our study. In addition, this study did not take into account deployments to other regions or outpatient care visits. The use of deployment as a marker of exposure is a broad and encompassing definition that does not allow for the specific exposure to disease associations necessary for the causal pathway to be established. Further

research into quantifying standard exposures found in certain occupations would be beneficial.

Finally, whereas data from only DoD facilities were used, research has shown that military personnel after the 1991 Gulf War did not separate from active military service at higher rates for medical disabilities.^(13,67) Further, military policy requirements are such that separating service members must undergo full medical evaluation, and any findings of ill health must be documented and reported to the service member.

Despite these limitations, our study has a number of strengths. Regular active duty personnel have ready access to medical care and are seldom hospitalized outside DoD facilities,^(12,68) affording us the opportunity to capture a thorough view of the hospitalization events for this population. Cox's proportional hazard modeling allowed us to estimate relative risks in the presence of many covariates and varying follow-up time. The adequate sample size afforded us robust estimations, with the exception of some of the specific diagnoses that were not our primary focus.

In summary, we found personnel deployed to Southwest Asia after the 1991 Gulf War to be at a slight increased risk for any-cause hospitalization and for 3 of the 14 major diagnostic categories when compared with veterans of the 1991 Gulf War. We also found personnel deployed to Bosnia to be at a decreased risk for any-cause hospitalization and at decreased risk for 12 of the 14 major diagnostic categories when compared with Gulf War veterans. This suggests that although risk for hospitalization may be associated with regional deployment, it is unlikely that Gulf War veterans are at greater risk of hospitalization due to a specific exposure related disease.

These findings demonstrate that we are yet to fully understand the health impact of military deployments on health care utilization. Although these results do not address whether differences in outpatient encounters exist, future studies, especially well-designed prospective studies such as the Millennium Cohort Study,⁽⁷⁰⁾ will better quantify deployment related morbidity in the U.S. military.

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14. ABSTRACT (maximum 200 words) Much attention has been given to the impact of deployment upon the health of veterans from the first Gulf War. While differences in self-reported symptoms have been common, no specific exposures have been implicated. Some have suggested that stress from deployment is the chief cause for multi-symptom conditions among 1991 Gulf War veterans. We sought to examine the impact of large military deployments upon hospitalization experience. Hospitalization records from October 1, 1988, through December 31, 2000, were examined for all active-duty personnel deployed exclusively to the Gulf War, Southwest Asia, or Bosnia. While these findings do not fully explain the complexity of postdeployment health experiences, they do not support the theory of a unique illness in 1991 Gulf War veterans.					
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